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ABSTRACT

This report carries the story of the establishment and expansion of the Schools Council-Nuffield Foundation project in primary mathematics (ages 5-13) up to the end of 1966, and looks ahead to the implications emerging for teachers, administrators, employers and parents. (Author/MM)

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FIELD REPORT No. **4**

Progress in primary mathematics

This report—a sequel to Field Report No. 1, 'New Developments in Mathematics Teaching'—carries the story of the establishment and expansion of the Schools Council-Nuffield Foundation project in primary mathematics up to the end of 1966 and looks ahead to the implications emerging for teachers, administrators, employers and parents.

THE SCHOOLS COUNCIL

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Introduction

Field Report No. 1 took the story of the background, planning and initial implementation of the joint Schools Council—Nuffield Foundation Project for primary school mathematics up to September, 1965. This was the scheduled date for the pilot areas to start work, although in fact they had already been in action for some months. This is a report on progress up to the end of 1966. It can only hope to describe superficially what has happened as so much has happened more quickly than could have been expected.

Sources

At the end of 1965, after one term's working of the project, the pilot areas were invited to send in to the Council an interim progress report. It was emphasised that this was complementary to specific feed-back about the draft Nuffield teachers' guides which had been sought by the project organiser. Returns indicated that the project had already made a considerable impact, especially, of course, on the participating schools and areas but also on other areas, and notably on other parts of local education authority areas which were operating a pilot area.

A list of headings, covering various aspects of the project's working, was offered to the areas. This list is given in an appendix, and much of the material in this report is based on the accounts sent in.

THE PILOT PHASE

Teachers welcomed the Council's Curriculum Bulletin No. 1 ('Mathematics in Primary Schools') and the Nuffield draft teachers' guides. In some cases certain lines of qualification on the guides were suggested, which had been conveyed to the project organiser or discussed with members of his team. The ways-and-means guide ('I do—and I understand') and 'Pictorial representation' are often spoken of as having been particularly helpful.

Teachers' centres

The effectiveness of the project's work has been increased by the use made of the teachers' centres. The positive responses given to the relevant headings in section B of the list testify to the influence of the centres. Evidence gained from visiting the centres and seeing the interplay between them and the schools supports this.

This 'centre influence' has still further revealed the strength of the profession in the teachers themselves—a strength which is enabling some experimental areas to start on their own initiative. But progress is not always easy and some areas have been disappointed or discouraged in the early stages. These initial difficulties can be overcome with outside help and mutual support at the teachers' centres, but they should not be underestimated.

Colleges of education

Particularly important, of course, is the partnership role that is played by the colleges of education. Already some links are being forged at the personal level, when lecturers share in the 'centre influence' in a locality, with advantages both to themselves and to the teachers in the schools.

Teachers

Discovery methods in mathematics are not new. They were evolved and practised over a number of years by pioneers in primary schools in many areas. The purpose of the project was to facilitate the spread of such methods to a number of experimental areas and thence more widely throughout the country, and the approach is described in Field Report No. 1.

The difficulties with which teachers have been confronted by involving themselves in these experiments must not be underestimated. Not the least has been the sheer weight of new reading material coming upon them—especially in joint areas for mathematics and science.

Content changes

It would be impossible to change over from a conventional, computation based method of teaching the elements of mathematics to a wider, discovery type of approach without automatically changing not only the flavour of a mathematics 'lesson' but its content also. The likely direction of such changes (e.g. widespread application of mathematics, at all levels of age and ability, to the environment, and the recording of results in a variety of ways) are described in the project's reading materials, and suggestions are also given for specific innovations. At the infant stage classroom evidence of the project's changes is largely seen in the more widespread adoption of the approaches to number and shape that have been inherent for many years in very many infant schools and classes. An increasing use of the word 'set' can be noticed fitting naturally into experiences of 'sorting'. Correct mathematical terms and phrases, even if surprisingly sophisticated sometimes, are heard from infants. The early use of graphical representation is developed, stage by stage, at infant level. And the particular innovation of 'mapping' has been given an extensive trial. Advantages are claimed for its use as an intermediate shorthand stage between a use of words to describe a mathematical operation and its result, and the eventual use of the conventional symbols of addition, subtraction, etc.

At the junior stage the project's changes are evidenced by the ways in which children's work follows a natural sequence; sometimes this includes their dealing with a succession of assignments. One of the most general and valuable activities of teachers, on courses and in their centres, is the planning, discussion, phrasing, and so on of assignments—together with the consideration of suitable environment and apparatus. In the main, teachers claim that the use of actual assignment cards has proved to be a necessary element in their classroom organisation. With the increase of experience, both their own and their children's, the use of assignment cards may decrease, but a general opinion is that there may always be some place at some time for some children for *good* cards—the significance of 'good' being that the assignments are as little directed in detail, and as open-ended, as possible.

Evidence in the classroom of widespread changes comes from the variety of situations to which the children are applying their mathematics—a variety which involves both observation of environment (whether inside or outside the actual classroom) and use of apparatus sometimes commercially built, more frequently home made (and inexpensively made!). It comes—very abundantly—from the different ways in which the mathematical results are recorded, of which a variety of graphical work is the most significant. For the great majority of the children, representation appears as an alternative, with obvious advantages, to recording in words; but because of the importance given to the interpretation and possible subsequent use of their graphs it gives a widespread chance of enhancing and improving their spoken and written English.

THE SECOND PHASE

With the pilot areas pursuing the work and enlarging the experiences of their final completed year, the large number (65) of second phase areas began their experimental activities in September, 1966. In due course they will be recording their experiences, and it has been suggested to them that in this they follow similar lines to the pilot areas. But in the months following their confirmation, late in 1965, of their acceptance of their part in the project, they had already accomplished a great deal in preparation for September, 1966. The central obligation of all (the provision of a centre) had been implemented by many authorities concerned. Their value had been gathered from the experiences of the pilot areas—often on visits to them by representatives of the second phase areas.

As with the pilot areas, the actual design of the second phase centres varies considerably from place to place. A few areas have experienced great difficulty in finding a suitable place; but the general pattern and purpose of the centres follow the line of the pilot area experiments, and great trouble has been taken to get a centre working as quickly as possible.

The second phase areas had, of course, the advantage of 'standing on the shoulders' of the pilot areas. They also had had longer to absorb the relevant literature—Curriculum Bulletin No. 1 had been available for more than a year, and they could use the Nuffield teachers' guides already issued in whatever sequence they thought best—whereas the pilot areas received them as they were issued.

Leader-representatives from the second phase areas attended initial courses similar to those arranged for the pilot areas. As in the case of these, two or three area organisers went to one of four centrally organised courses, two of these being for areas opting for mathematics only, two of them for those areas who were going to do science only or mathematics and science. But the pattern for the second round of courses, to which some ten or twelve representative leaders came from each area, had to be altered because the large number of areas concerned made it impossible to service them all centrally. Consequently, as recorded in Field Report No. 1, centrally arranged courses were organised for the areas concerned solely or jointly with science; while the 'mathematics only' areas were invited to courses organised and run by teachers and local authority officers from the four consultative areas of Devon, Dorset, Nottingham and Sheffield, together with one course organised and directed by Miss Irene Campbell of the Worcester College of Education.

There were altogether seven of these locally run leaders' courses, Nottingham and Sheffield doing two each. They were all different from each other, although serving identical purposes. They all brought out the possibilities and variations of local initiative; and their success underlined a belief in the efficacy of local or regional effort and talent on which the extension will have very largely to depend. Much is owed to the directors and staffs of the courses for the thought and detailed planning that contributed to their success.

THE CONTINUATION PHASE

The first batch of teachers' guides prepared by the Nuffield team will be published in 1967 after revision in the light of the trials. In anticipation of this, a letter went out from the Council in November 1966, asking local education authorities whether they would wish to take part in extending the project beyond the pilot and second phase areas, and indicating the sort of in-service training facilities which would be required.

In response, considerable readiness to co-operate was quickly shown.

FOR THE FUTURE

1. Films for training teachers

An authority or college (or parent-teacher association) may find it useful to have a list of the films made about the teaching of mathematics to young children. They are:

'I do—and I understand'—a 15 minute film made for the project, showing a mathematics lesson in a school where one of the Nuffield team members taught. Copies may be obtained on free hire from the Petroleum Films Bureau, 4, Brook Street, London, W.1.

'Maths alive'—a 30 minute film sponsored by the Department of Education and Science. This shows children of ages 5 to 11 learning mathematics by discovery methods. Copies are available for purchase (about £65) or hire (about £25.0.) from the National Council for Audio-Visual Aids in Education, 33, Queen Anne Street, London, W.1.

'Children and mathematics'—a series of five 30 minute television programmes, prepared by the BBC in conjunction with Dr. Matthews, the Nuffield project organiser. They are designed primarily to help teachers in infant, junior and the early years of secondary schools. The films are distributed with a booklet of notes and a large list of discussion points which they raise. Many authorities taking part in the project have purchased sets of these films, which are not so far available on hire. Copies of them may be bought from BBC Television Enterprises, The Television Centre, White City, London, W.12, price about £35 each.

The individual titles are: 'We still need arithmetic'; 'Common sense and new maths'; 'Freedom to think'; 'Checking up'; 'Teachers at the centre'.

'Maths is a monster'. BBC 1 edition.—This shows large classes of children at work in a junior school. The emphasis is on the use of children's interest in the developing of mathematics. Careful attention is paid to progression.

2. Evaluation

There are three distinct aspects:

- (i) *For the teachers using the materials.* Many of the teachers taking part in the project feel a pressing need to be able to make some assessment of their own individual pupils' progress in learning mathematics. Much thought is being given to this in all the pilot areas. Meanwhile, the Nuffield Foundation, with the Council's help, has enlisted the co-operation of Professor Piaget's Institute in Geneva in a joint attempt to construct and try out a range of 'check-ups' to meet this need. The Institut des Sciences d'Education in Geneva has considerable experience of research into how children form concepts, including concepts in mathematics. Some of their research workers are undertaking a detailed examination of the Nuffield junior mathematics project material, to study the sequence of concept formation which it implies. Trials of the first 'check-ups' have begun in a few schools in the pilot areas. These will be offered for use by class teachers as an integral part of the project work.
- (ii) *For the curriculum development team.* The Nuffield project team are, of course, receiving information from the teachers and pupils using the trial materials, and incorporating their criticisms and suggestions in the revised editions.
- (iii) *For the teaching profession as a whole.* As the project progresses, teachers at large, who have not themselves been concerned in the trials stage but are interested in it, will wish to have evidence about several points. For example, the extent to which it achieves other desirable objectives in mathematics teaching (i.e. apart from those which it specifically set out to achieve), and how far other kinds of teaching are successful in achieving either or both of these.

Because there may be differences between the objectives of the project and those of other kinds of mathematics teaching, it is not possible to carry out a simple comparison to show whether one is, absolutely, 'better' than the other. But an evaluation which explained and illustrated the successes (and weaknesses) of each would enable teachers to judge independently whether the project helped pupils to learn the kind of mathematics which they (the teachers), or the Council, or society at large, believed to be important—and whether it did so to a greater or lesser extent than other kinds of teaching.

Some aspects that would be included in such an investigation—such as pupils' interest in mathematics and the way in which their knowledge and interest in the subject affected their school and subsequent career—might well merit further investigation over a period of time.

3. Secondary schools

The responses from the areas, and evidence gained from visiting them, shows that there is a wide variation at present in the involvement of secondary schools. This is natural as the guides so far have covered only the earlier stages of the learning of mathematics.

There certainly is a growing realisation that secondary schools must find out about the changing mathematical achievements of their contributing primary schools as this will affect the attitude and attainment of the children they receive.

There is also a realisation that readjustment in curriculum and method have to be thought of in the context of the Certificate of Secondary Education, of the raising of the school leaving age, of reorganisation problems (not least when middle schools come to be considered in detail), and, of course, of changes in content of the mathematical curriculum.

The Council has commissioned a development project to help the teaching of mathematics in secondary schools to pupils between the ages of 13 to 16 with particular reference to pupils of average and below average ability. This work will be carried out at Exeter University, and will be led by Mr. P. Floyd, previously a senior lecturer at Rolle College of Education, Exmouth. Mr. Floyd has just completed a year's study of the possibilities in this field, at the Council's request. The work of this project (to be called the Secondary Schools Mathematics Project) will relate to that of the current project for the 5 to 13 age range, and it will inevitably call for closer and closer links between those responsible for children's learning of mathematics whether they teach in a primary or in a secondary school.

4. Science and mathematics

Mathematics lessons are frequently planned and carried out in accordance with scientific principles and method and science lessons (whether named 'science' or 'mathematics') frequently need to call in mathematics to process their situations. Whether the experimental areas are designated mathematics, science or joint, the children are as often as not working on problems which they would find it difficult to distinguish as 'mathematics' or 'science'.

This is in sympathy with the overall development in primary schools during the past ten years: that is, the general tendency to integrate different aspects of the curriculum. And in the secondary schools, one large secondary school in one of the pilot areas is experimenting with the integration, as reflected in the timetable, of science and mathematics for its younger pupils.

Meanwhile the teaching materials in science prepared and tried out in the Science Project pilot area schools last year (1965/66) will be published in time for September 1967. And the Council hopes to suggest ways of helping interested teachers to find out about these materials, partly through contact with the trial areas.

To follow up the Nuffield Junior Science Project, the Council and the Nuffield Foundation are sponsoring a development project starting in September 1967. This team will be based at Bristol University under the leadership of Mr. L. F. Ennever, who has resigned from H.M. Inspectorate to take on the work. The team are likely to develop materials for trial in much the same way as the science project just finished, and consideration will be given to helping primary school teachers to increase their own knowledge of science.

5. Staffing

A recognition of a new position for the teacher is forcing itself on the primary school world where the project has made an impact. The teacher is seen as having responsibilities, in the interest of his own and other people's pupils, outside his school. This has already arisen where teachers have worked for regional CSE committees. Now it occurs when primary school teachers attend for in-service training at their local centre or elsewhere in school hours.

How is their school work to be carried on so that neither their pupils nor their colleagues suffer unduly? Teachers attend a sequence of courses in mathematics either wholly in their own time, partly in their own time, partly in school time, or wholly seconded. The latter is particularly helpful in the case of married women with families, but difficulties do arise for the schools concerned, especially for the very small schools. The use of part-time or peripatetic staff to fill temporary gaps is a tempting solution, but it does not always prove easy to put into practice. Often the school concerned has to rely on its own goodwill and good sense, and arrangements are made as they have to be made in the case of illness. One thing stands out: provided the course is worthwhile the trouble involved does in the long run benefit those in the school itself.

6. The centres

In a year or two, a description of the growth of teachers' centres ought to make an interesting topic for study. Their variety, their almost instant acceptance by teachers, as a natural adjunct to their professional life, and their acceptance by the authorities, as a natural educational facility for them to provide and maintain, are all important. At the moment it is sufficient to record that, in their variety from single rooms to parts of extensive premises devoted to a generality of teachers' interests, they have made a decided impact not only on the teaching of mathematics and science but on other subjects where there has been an extension of interests. The co-operation between staffs of different schools and between the various partners in education—teachers in schools (infant, junior, secondary, special), teachers in colleges of technology and of education, local education officers, organisers, administrators, inspectors, and HMIs has been most valuable.

In fact, the centres are showing how to operate locally and regionally the essential purpose of the Schools Council itself—to enable the various partners of education, wherever they may be working, to share each others' problems and each others' successes, and to provide from among themselves whenever possible the talents necessary to ensure the survival of present good enterprises and, out of their imagination and initiative, to devise others.

At present, as centres are set up, some of the experimenting authorities, whether of the pilot or the second phase, are faced with the problem of how to staff them. Even within the original context of centres set up specifically for the mathematics or science projects, the work needed to service them has expanded enormously; but already a number of authorities are planning their centres in wider curriculum contexts, with a view to the raising of the school leaving age. In many cases part- or full-time secretaries (or wardens) have been appointed, some of them practising teachers, wholly or partly seconded, and some retired teachers. There is of course considerable variation in the nature and extent of the problem in the centres and it is in keeping with our flexible system of education that these should be met in a variety of ways.

The Schools Council/Nuffield Foundation 5-13 Mathematical Project
Some suggested headings for progress reports from
the pilot and second phase areas

A. The project materials

1. The teachers' guides.
2. Curriculum Bulletin No. 1 ('Mathematics in Primary Schools').

B. Use and value of the teachers' centres

1. Organisation of use of the centre by teachers in the pilot schools.
2. Use of a 'workshop' room by (i) teachers; (ii) children.
3. Use of a centre for practical sessions, discussions, lectures, films, exhibitions.
4. Setting up working parties for specific enquiries with regard to the project; teachers' 'homework'.
5. Use of the centre in connection with personal reading.
6. Extension of the centre's use to matters of teachers' interest other than mathematics.
7. Formation of sub-groups, especially in rural areas.

C. Influences of the project on school organisation

1. Systems of children working in groups—either *started* as a result of the project, or continued in the project, or *strengthened* by the project.
2. Organisation of the actual work done in the classroom; assignment card systems (e.g. Who compiles the cards? How are they used? etc.); discussion periods with the children, formal or informal; periods specifically earmarked for computation practice and so on.
3. Any particular impact of the project on streamed or on unstreamed or (especially in a small rural school) on multi-age classes.
4. Impact of the project on timetabling.
5. Impact of the project on the use of buildings and furniture.
6. Methods of use of apparatus; including Multiboards and calculating machines.

D. Human reactions to the project

1. Children.
2. Teachers.
3. Parents.
4. Secondary schools.

E. Various

1. Inter-visitation by area organisers and teachers from the pilot school, whether within the authority's boundaries or beyond them.
2. Teachers' assessment of children's progress.
3. Value of a local information bulletin (whether actually in existence or merely suggested). Possibilities (actualities?) of local film-making.
4. Influence of the project on other parts of the curriculum.
5. Influence on the project of the local staffing situation.

(This list of headings is not meant to be exhaustive; information on any aspects of the project's work not covered by it will be welcomed.)